VIRGINIA GIS REFERENCE BOOK

General Application Name: Public Works/Service Authority

Product / Service / Function Name: Water and Sewer Service Areas

P/S/F Description:

Water distribution and sanitary sewer service areas are regions that are served by specific public works departments or service authorities. Service areas can be divided into sub-basin areas, often delineated by drainage basin extents. Customers within water and sewer service areas include residents, businesses/commercial organizations, and industrial organizations. The agency responsible for maintaining the service areas must take on several tasks. They must provide water and wastewater services to customers while also maintaining infrastructure, complying with environmental and jurisdictional regulations, handling customer complaints, and maintain a fair billing system. GIS is an ideal technology to manage this type of infrastructure. Water and wastewater systems contain linear and spatial features so not only can the infrastructure inventory be maintained but also modeling can be performed to predict and plan for future service area needs.

Product / Service / Function

1. Spatial Data

Minimum Data Requirements

General Description	Data Layer
Utility Data	Water Service Areas
	Sewer Service Areas
	Water Mains
	Sewer Mains
Planimetrics/Base Mapping	Parcels
Transportation	Right-of-way and/or edge of pavement
Socio-Political Data	Municipal boundaries
Natural Features	Streams/rivers
	Ponds/lakes
Other Data	Digital Orthophotography

Optional Data Requirements

General Description	Data Layer
Utility Data	Water valves
	Manholes
	Storm water drainage
	Treatment plants/pump stations
	Tanks/wells
	Fire Hydrants
	Water Meters
Planimetrics/Base Mapping	Zoning
Transportation	Centerlines

Socio-Political Data	Neighborhoods & Subdivisions
Other Data	Digital Orthophotography

2. Attribute Data

Minimum Attribute Requirements

General Description	Field Name
Sewer Service Area	Unique ID
	System ID
	System name
	Area
	Perimeter
	Description
	Number of residential customers
	Maximum daily flow
	Average daily flow
	Owner
Water Service Area	Unique ID
	System ID
	System name
	Area
	Perimeter
	Description
	Water supply source
	Maximum daily flow
	Average daily flow
	Owner
Right-of-way	Street names
Water Mains	Material
	Diameter
Sewer Main	Material
	Diameter

Optional Attribute Requirements

General Description	Field Name
Sewer Service Area	Number of residential customers
	Average monthly charge for non-residential customers
	Average monthly charge for residential customers
	Average monthly charge for non-residential customers
	Average monthly charge for bulk purchase customers
	Average monthly usage for residential customers
	Average monthly usage for non-residential customers
	Average monthly usage for purchase customers
	Problems
	Engineer recommendations
	Estimate to implement recommendations

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	Expansion of service area
	Projected maximum daily flow
	Projected average daily flow
Water Service Area	Number of residential customers
	Average monthly bill for residential customers
	Average monthly bill for non-residential customers
	Average monthly bill for bulk purchase customers
	Problems
	Engineer recommendations
	Estimate to implement recommendations
	Expansion of service area
	Projected maximum daily flow
	Projected average daily flow
Neighborhoods & Subdivisions	Names
Water Mains	Length
	Slope
	Roughness coefficient
	Pressure rating
	Minor Loss
	Service Area
	Water Type
	Depth
	Ground Surface Type
	Lining Type
	Joint Type
	Install Date
Sewer Main	Length
	Slope
	Roughness coefficient
	Pressure rating
	Minor Loss
	Service Area
	Water Type
	Depth
	Ground Surface Type
	Lining Type
	Joint Type
	Install Date

3. Data Acquisition Options

For water and sewer service areas, two main data layers should be created. First, the actual service areas would best be depicted as polygons. These can be digitized "free hand" based on the GIS operator's knowledge of the service area boundaries or the boundaries can be scanned from an existing map and digitized into the system. For the actual water and sewer systems, most efficient way to develop new GIS data layers is to obtain the original source data, such as existing maps, drawings, or as-builts, and scan them with a large format scanner. Then, the as-builts should be geo-registered (see conflation section below), and digitized as a new data layers.

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Descriptive information from the paper files or attribute information from other hardcopy or digital sources can be added to the GIS layer's database attributes during the digitization process. The use of orthophotography during the digitizing phase is extremely useful and timesaving for locating features on the ground that correspond with features on the scanned map.

Street centerline data layers of varying qualities can be obtained from a number of vendors. The market is relatively competitive, and prices will vary with quality of the data. Relevant vendors that provide this kind of spatial data on a regional and national scale include: NAVTECH <www.navtech.com>, GDT <www.geographic.com>, and TeleAtlas <www.teleatlas.com>.

Parcel data are typically maintained at the county level, and are often distributed free of charge to other government agencies. Other spatial data layers (i.e., streams/rivers, municipal boundaries) can be obtained through the Internet or directly from various external sources. Before using data from external organizations it is important to assess data scale, accuracy, precision and geographic coverage.

Regardless of the source of the data, each data layer used for this project should be consistent with, or be modified to match, the projection of the Virginia Base Mapping Project orthophotography. This is vital for data consistency across the state and it facilitates data sharing across jurisdictional boundaries.

4. Data Conflation Options

Data conflation is a process by which two digital data layers, usually of the same area at different points in time, or two different data layers of the same area, are geographically "corrected" through geometrical and rotational transformations so that the different layers can be overlaid on one another. Also called "rubber-sheeting," this process allows a technician to adjust the coordinates of all features on a data layer to provide a more accurate match between known locations and a few data points within the base data set. A good base layer to use for data conflation is the VBMP orthophotos since many features can be seen or interpreted. The need and processes for conflation varies between sets of data, users, and feature types. Any dataset that is updated independently by different departments can be consolidated through conflation. Within most local governments, individual departments are responsible for maintaining specific datasets within their expertise; therefore, conflation is not often necessary. Often, reprojecting the data into a different coordinate system will take care of the misalignment of different data sets. Most industry-standard GIS software has the ability to perform data conflation.

It is important that the sewer and water service areas and pipelines are captured or reprojected in the projection defined by the Virginia Base Mapping Project. This ensures that the service area layers will correctly align with the orthophotos and provide a "bird's eye view" of the water and wastewater systems within a service area.

5. GUI / Programming Options:

There are many options for developers of a GIS-based water/sewer service area maintenance application. Three avenues within this development track are:

- Standard GIS desktop software that can be customized to the user's needs
- Existing commercial applications.
- Hiring a consultant to develop a custom system from scratch.

Using a standard GIS software package often requires a significant amount of training and customization. Whereas the initial cost may be lower, the time invested in learning these solutions may generally increase the overall expense of implementation. However, standard GIS software packages deliver more robust data integration, analysis, and cartographic capabilities than do other specialized commercial applications. They have a greater user support infrastructure that allows users to overcome problems quickly. Options for using an existing, industry-standard GIS software application that can be customized include the following:

Standard GIS Software Vendors:

Vendor	**Software**	**Web Address**
ESRI	ArcView 3.x	http://www.esri.com
ESRI	ArcGIS 8.x	http://www.esri.com
MapInfo	Professional 7.0	http://www.mapinfo.com
Intergraph	GeoMedia 5.0	http://www.intergraph.com/gis
Autodesk	Map 5.0	http://www.autodesk.com

There are an increasing number of vendors developing and implementing utilities management software. These products may cost more than standard GIS solutions because of the customization that is required to fit the application into the agency's business practices and/or connect to its data source. The advantage is that a tailored application provides just the functionality that is needed, decreasing the overall application overhead common to industry-standard GIS software. Options for using existing commercial utilities management software include the following:

Commercial Software:

Vendor	**Product**	**Web Address**
RPT, Inc.	GeoPlan	http://www.rpt.com
Azteca	CityWorks	http://www.azteca.com
CarteGraph	WATERview	http://www.cartegraph.com
Hansen	Hansen 7.5	http://www.hansen.com

The final option for developing and implementing a utilities management application is to contract a consultant. This option makes certain that a product will fulfill a jurisdiction's requirements. A consultant will be able to develop an application that works with the wide range of hardware and software that are currently in use within local governments within Virginia. Also, training and follow-up user support is often provided at a much more substantial level than with other options.

In addition to printing quality service area maps efficiently, there are several customization possibilities for a water/sewer service area management application. Sample functions include:

- Maintain infrastructure inventory for water/sewer equipment
- Create and track work orders for repairs
- Maintain history of repairs
- Aid in master planning and capital improvement project planning
- Analyze the history and trends of water/sewer use within the service area

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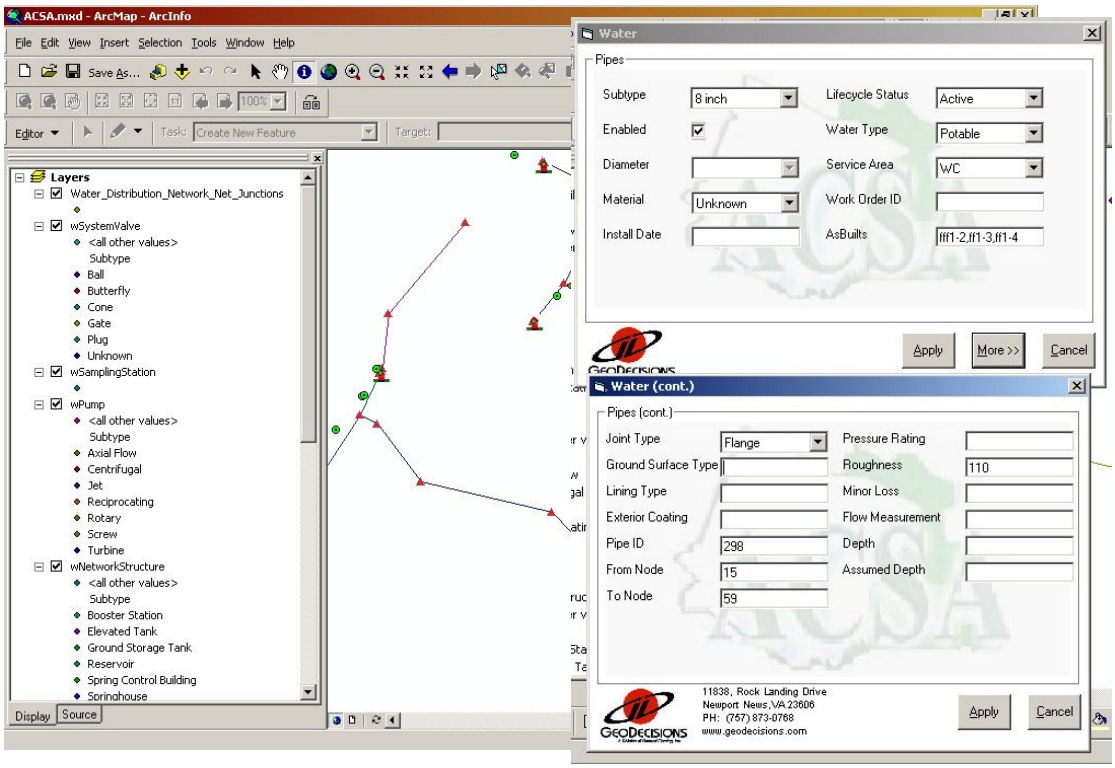
- Integrate GIS functions with a third-party modeling software to provide robust modeling options
- Integrate the water meter billing system data with the meter data layer in the GIS to study water usage trends and automate billing
- Produce notification letters for a water service shutdown via mail merge



A custom interface for ESRI's ArcGIS to facilitate user-friendly editing of the water utility data.

6. Internet Functionality and Options:

The Internet has proven itself as a viable solution for local governments to centralize the maintenance and management of services and data. As more local governments are implementing Web-based solutions, they are finding that the Internet requires them to change the nature of an application or its usefulness. Through the flexibility of an Internet solution, software can be easily updated, and users gain greater accessibility to the applications and information they need for their specific tasks through simple, user-friendly interfaces.

While desktop applications are mainly for staff and "power users," an application can be deployed on the Web to allow greater access to this information for the community. While not all of the information can be made public (depending on confidentiality), it is very common for municipalities to offer interactive maps of the water/sewer system and service areas online. Additional possibilities include uploading current map on repair projects and outages or even provide customers access to their water/sewer billing information online. GIS software vendors have products that can be customized in-house or by a consultant to provide Web GIS applications on the Internet, over an intranet or via wireless network. The table below shows GIS vendors and their Internet mapping solutions.

GIS Internet Solutions

Vendor	Internet Software	Web Address
ESRI	ArcIMS	http://www.esri.com/software/arcims
MapInfo	MapXtreme, MapX	http://www.mapinfo.com
Intergraph	GeoMedia WebMap	http://www.intergraph.com/gis/gmwm
Autodesk	MapGuide	http://www.autodesk.com

7. Technical Requirements

Minimum Technical Requirements
At its most basic level, a water/sewer service area maintenance application can be used on a single, stand-alone workstation. This workstation would have a hard drive that stores all of the spatial data layers, as well as a database containing a copy of all of the incident records for the law enforcement agency. A typical workstation running off-the-shelf software should have the following minimum specifications:

Processor: Pentium 3, 450 MHz
RAM: 128MB SDRAM at 133MHz
Hard Disk: 20GB (min.)
Monitor 1: 19"
Floppy Drive: 3.5”
CD-ROM: 12x/8x/32x CD drive
Modem: 56K
OS: Windows 2000/NT/XP
Office: Windows 2000 Professional
Printer: 8x11 office-grade color printer

Optimum Technical Requirements:
A more complex system may require multiple components, including servers, desktop workstations, ruggedized laptops, and/or handheld devices. For either a client-server or a Web-based application, the system should rely on a fairly robust server computer and high-end workstations. Some examples specifications of the necessary equipment are listed below:

Server
Processor: Min. 2x Processors, 1.7 GHz, 512K cache
RAM: Min. 2x 512MB RIMMS
Hard Disk: Min. 2x 80GB +RAID
Monitor 1: 19"
Floppy Drive: 3.5”
CD-ROM: 12x/8x/32x CD drive
Modem: 56K
Network Card: 10/100 mbps

Workstation
Processor: Pentium 4, 1.5 GHz
RAM: 512MB SDRAM at 133MHz
Hard Disk: 20GB (min.)
Monitor 1: 19”

Monitor 2: 17”
Floppy Drive: 3.5”
CD-ROM: 12x/8x/32x CD-RW drive
Modem: 56K
Network Card: 10/100 mbps
OS: Windows 2000/NT/XP
Office: Windows 2000 Professional

Other Components
Printer: 8x11 office-grade color printer and 8x11 production b/w printer
Plotter: HP DesignJet 1055CM
Tape Backup: Tape Library Server
UPS: APC 1400 (or other similar)
Scanner: 11x17
Handheld: Compaq IPAQ
Network: T1
GPS Equipment: Receiver, Antenna, Data Processing software (various vendors)

8. Administrative/Management Requirements

At the beginning of the project the assigned project manager should consider completing some, if not all of the following tasks that relate to the administrative requirements of a water/sewer service area maintenance application:

- Determine, with or without the assistance of a consultant hired to develop the system, the preliminary vision and goals of the project.
- Coordinate an initial meeting with the decision-makers (i.e. the Board of Supervisors, City Council, public works department, engineering department, etc.) where the vision and goals of the project are expressed and the background of GIS technology is described, if needed.
- Coordinate with other municipal agencies for data sharing provisions.
- Determine a mechanism of communication to keep the decision-makers aware of the progress of the project.
- Develop a basic understanding of the available precedents in the region/state and research the available technologies that can be applied to the project

Upon project completion, a simple desktop application will require very little administrative support. Administrative tasks may include loading or upgrading new versions of the software or patches, providing for constant data flow from the other systems, and maintaining yearly support contracts on the hardware and software. However, once the system becomes widely distributed, there are various other management requirements that need to be fulfilled on a weekly or monthly basis.

At the point where the system grows beyond single desktop users, a devoted administrator or system manager needs to be established. This is essential for the following reasons:

- The system will now be interfacing with other technology systems already in place and therefore, someone needs to maintain contact with the technology personnel that maintain these systems.

- The manager needs to put into place quarterly training schedules to maintain user knowledge of the system.
- Funding will undoubtedly be required to either maintain the system long-term, or continue to expand the system, which requires funding research and applications for grants.
- Utility systems only succeed when it is implemented on a weekly basis with rigorous analysis and planning.

9. Cost – Cost/Benefit

Hardware	**Typical Unit Cost**
Minimum Workstation	$2,000
Optimum Workstation	$3,200
Laptop	$2,400
Web/FTP Server	$8,500
Database Server	$12,000
Data Warehouse Server	$18,000
Backup Server	$5,800
Printer (8x11 color)	$700
Printer (8x11 b/w production)	$2,000
Plotter	$12,000
Tape Library	$5,000
UPS	$700
Scanner	$1,500
Handheld	$300-$700
GPS Equipment	$4,000 - $12,000

Software (all prices included license)	**Typical Unit Cost**
Standard GIS desktop software	$700-$10,000
Commercial application	$2,000-$6,000
Customized vendor solution	$5,000-$15,000
Web-based vendor application	$15,000-$25,000
Customized web-based vendor solution	$20,000-$60,000

Miscellaneous	**Typical Unit Cost**
Training – focused vendor application (per person)	$7,00-$1,000
Training – general GIS	$700-$1,200
Licensing-desktop	$100-$500
Licensing-webapp (1st CPU)	$7,500-$12,000
Maintenance (per year)	$8,000-$15,000

10. Standards / Guidelines Summary

- If digitizing from scanned utility drawings/maps, use a minimum of four reference points when registering the images.
- The water/sewer system data layers should be cleaned to ensure that all features are properly snapped together. Otherwise, difficulties may be encountered while running hydrologic models.

- Always maintain a unique identification number with every spatial feature, and event recorded within the system.
- Standardize naming conventions for data sets, feature names, and codes.
- Standardize the directory structure of the GIS server.
- Develop installation and distribution procedures.
- Standardize data entry and editing procedures. Data entry procedures will need to be integrated with staff work routines to promote accurate and reliable spatial and attribute data when developing new data sets or updating existing datasets.
- Develop a detailed Quality Assurance/Quality Control (QA/QC) procedure for reviewing the accuracy of the GIS data and its attributes.
- Maintain data in the VBMP standard coordinate system (Virginia State Plane, NAD 83, Survey Feet).
- Create metadata (standard information about GIS data) for each data layer. Metadata tracks the date, origin, coordinate system, and other such information for data layers.

11. Startup Procedures/Steps

There should be a minimum of eight steps involved with water/sewer service area maintenance application after funding is in place to support the project. The steps can be performed in-house or by a consulting team.

The first task is to complete a detailed Needs Assessment. This process gathers information regarding existing operational procedures, hardware and software, existing sewer and/or water service area data, and personnel needs. It should include interviews of key individuals to obtain a comprehensive view of the agency's operations, and where GIS might improve them. Basic GIS concepts should be discussed and illustrated to those interviewees that have little prior understanding of GIS. A comprehensive Needs Assessment should then be compiled from the results of the interviews. This document explains the various requirements for a water/sewer service area maintenance application in the following areas: personnel needs, spatial data development needs, application functionality requests, basic system requirements, including preliminary, general hardware and software recommendations, and training needs.

The second task is to develop a functional requirements document for the proposed system. This document should describe, as completely as possible, all of the technology and functionality that is to be included in the system. This document is used by the local government agency, or its consultant, as the blueprint for the GIS application or system. It should include:

- Hardware specifications
- Software purchases
- Detailed descriptions of work-flow, and examples of the graphic user interfaces
- Describe each tool that is part of that graphic user interface, and its functionality
- Describe how data would flow between the different databases and data warehouses, if applicable
- Describe the redundant security measures that will be put in place to make certain of data integrity and confidentiality, when applicable
- Analytical techniques that the application/system provides the user for analysis
- Describe each of the potential products (reports, maps, charts, summary tables) that the user will be able to generate within the system

The third task should be to compile or develop spatial data that can be used by the evolving application. Data can be gathered from a number of online sources, as well as county/city departments. The data layers gathered and maintained should match at least the minimum list provided in Section 1 of this document and can be acquired through the methods described in Section 3 of this document.

On completion and acceptance of the functional requirements document and the development of the spatial and attribute data, the system development and test phase can begin. During this time, the application will be customized as it was outlined in the functional requirements phase. The local government agency should require periodic reviews of the application at particular milestones, such as 50% and 75% completion. This will make certain that problems with the application will be recognized early in the development process, and that the local government agency remains a part of the development process throughout the project timeline.

When the application is nearing 100% completion, it should be installed and tested in the environment in which it will ultimately be used. This allows the users to test the system alongside the application developers, and determine any system integration problems that might arise. It also gives the developers the opportunity to test the application's functionality in a real-world situation. This testing process should be as comprehensive as possible. Each process detailed within the functional requirements should be tested and evaluated at this point.

User training commences once the application reaches 100% completion and is fully documented. Different levels of tutorials and system documentation should be developed depending on the hierarchy of users. Time should be spent at this stage of the project with each potential user of the system to make certain that the proper education occurs. Training should be done through lessons that use real-life examples of system application. This strategy greatly enhances users' ability to apply the functionality to their jobs.

The next phase of the project should include a document that describes a future plan for wider system development. This document accomplishes two goals. The future plan gives the local government agency ideas on how the system might grow to assist other facets of its business practices. Secondly, it provides the agency with a ready-made grant proposal for applying for potential funding sources.

The final phase of a successful water/sewer service area maintenance application is ongoing technical support. The agency should always include this contingency within its cost estimates of a project for a minimum of three months after a system has been put into place. No matter how effective an application appears, problems and system changes inevitably impact the functionality of a system.

12. Estimated time line and/or implementation (stand alone) schedule:

Phase	**Duration**
RFP/Contract process (construction, posting, proposal acceptance, review, award of contract)	4 months – 12 months
Needs Assessment	1 months
Functional Requirements	1-2 months
Data Development	2 months
System Development and Testing	2-4 months
Installation and Testing	½ months

User Training	½ month
Plan for Future Development	½ month
Ongoing Support	3 months

13. Best Practice Examples in Virginia

Augusta County Service Authority
18 Government Center Lane
Verona, VA 24482
540-245-5670
http://www.acsawater.com

Spotsylvania County
Department of Utilities
600 Hudgins Road
Spotsylvania, VA 22408
(504) 898-2053
http://www.co.spotsylvania.va.us

Henrico County
4301 E. Parham Rd
Richmond, VA 23228
(804) 501-5769
http://www.co.henrico.va.us

City of Hampton
Public Works
22 Lincoln Street, 4th Floor
Hampton, VA 23669
757-727-8311
http://www.hampton.va.us/publicworks/wastewater_gis.html